A modeling approach to determine how much UVB radiation is available across the UK for the cutaneous production of vitamin D

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Outline of presentation

- Information about the project
- Methodology to determine the available radiation across the UK
- Validation of results
- Conclusions – Future Work

Information about the project

- Title – Principal aim: “Modeling approach to determine the duration and intensity of sunlight exposure required to maintain and achieve adequate vitamin D status in winter in “at risk” populations”

- Scope: to inform the forthcoming risk assessment report from the Scientific Advisory Committee on Nutrition (SACN) on Vitamin D and Health

- Research questions:

How much UVB radiation is available across the UK?

To how much of this radiation are people exposed?

What effect does this have on vitamin D status?

How much exposure is required to avoid low vitamin D status during winter and does this pose health risks?

Research work related to modeling in this project

- Question: How much UVB radiation is available across the UK?

- The answer is based on:

Radiative transfer model runs of UV radiation (as a function of latitude, altitude, season, time of the day, surface albedo, ozone, aerosols and clouds)

Validation of modeled results with ground-based measurements

Methodology

- Selection of an extensively tested and well-validated radiative transfer model.

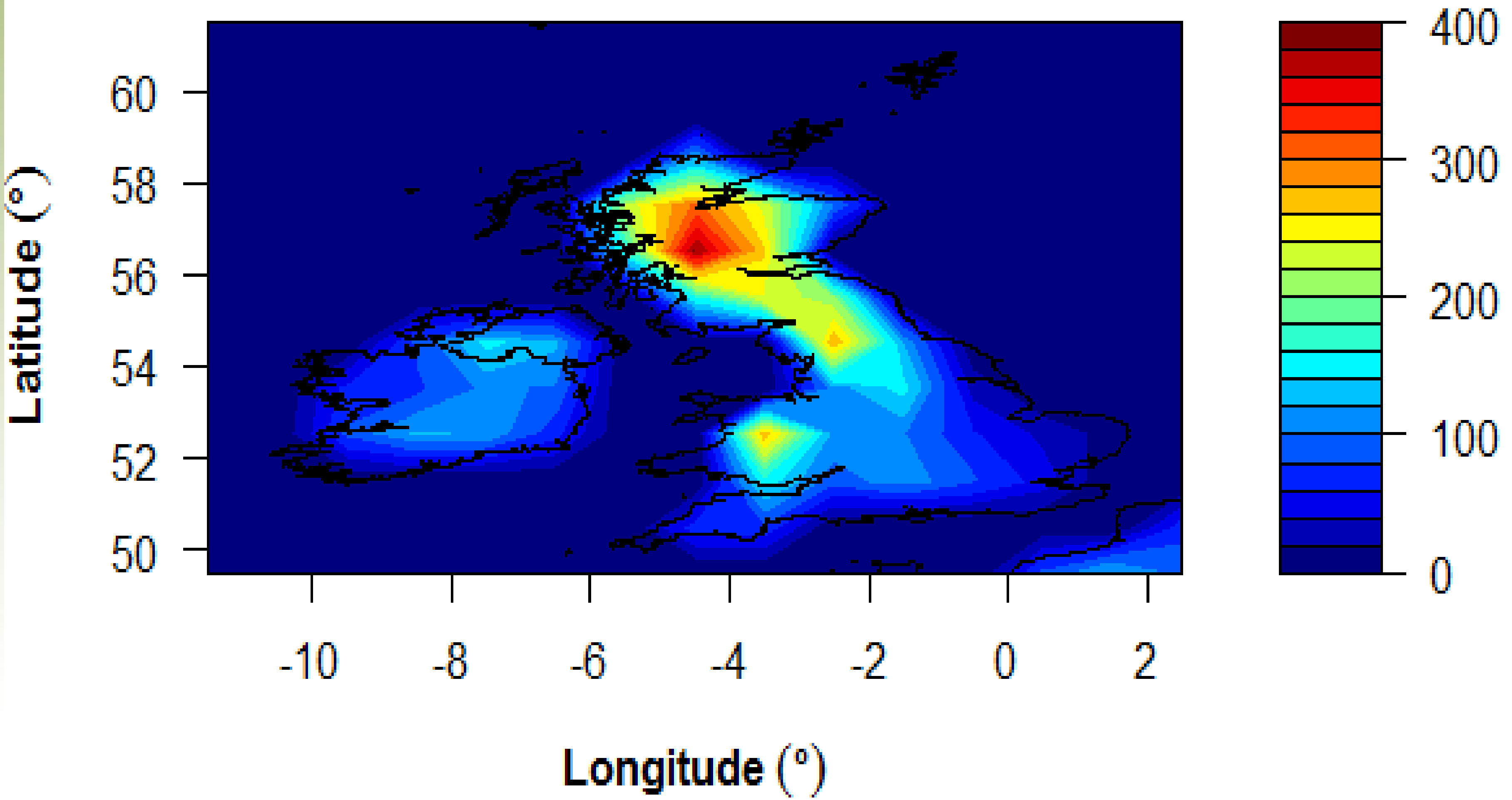
- Determine the appropriate climatologies for ozone and aerosol optical properties

- Use of daily data for cloudiness (cloud fraction, cloud optical depth)

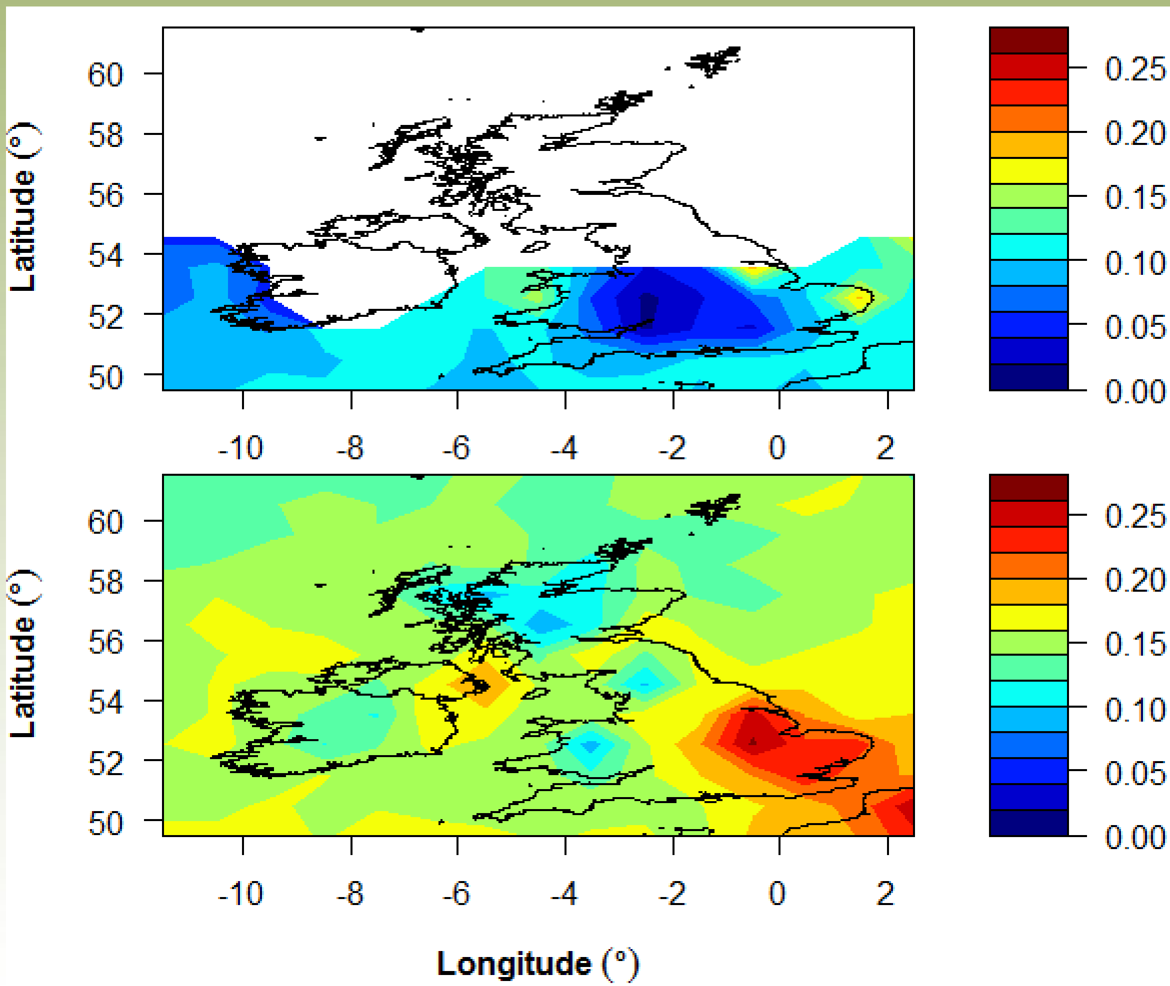
- Calculations of 3 types of daily doses (vitamin D, erythemal, DNA damage) using the radiative transfer model (time step: 30min) with spatial resolution 1°x1°, for a sufficient time period to derive the UK UVB climatology

Model inputs: surface altitude (1x1°) from GTOPO30 digital elevation model

Surface altitude (m)



Model inputs: the MODIS aerosol optical depth (550nm)



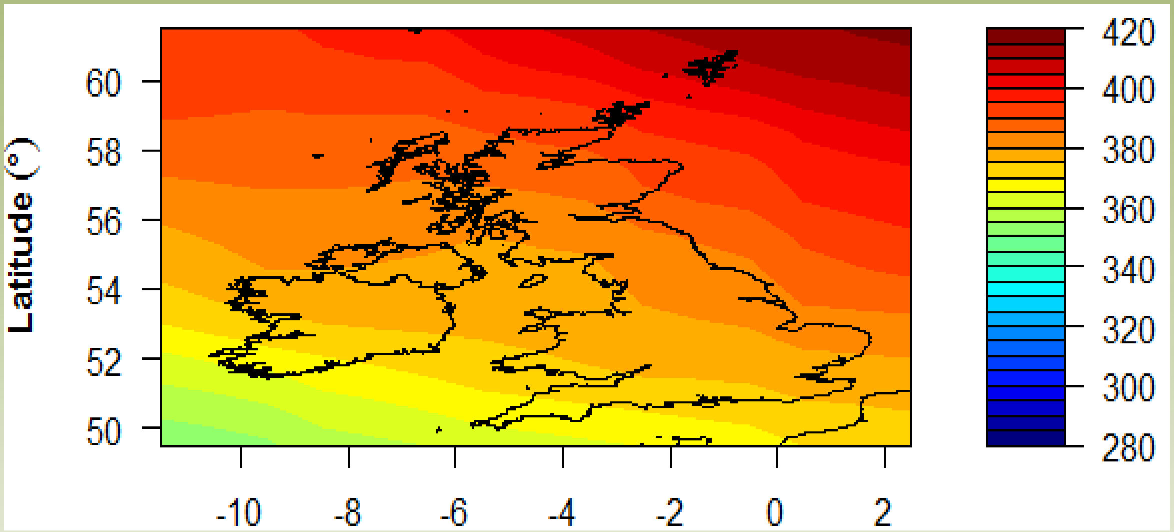
January

July

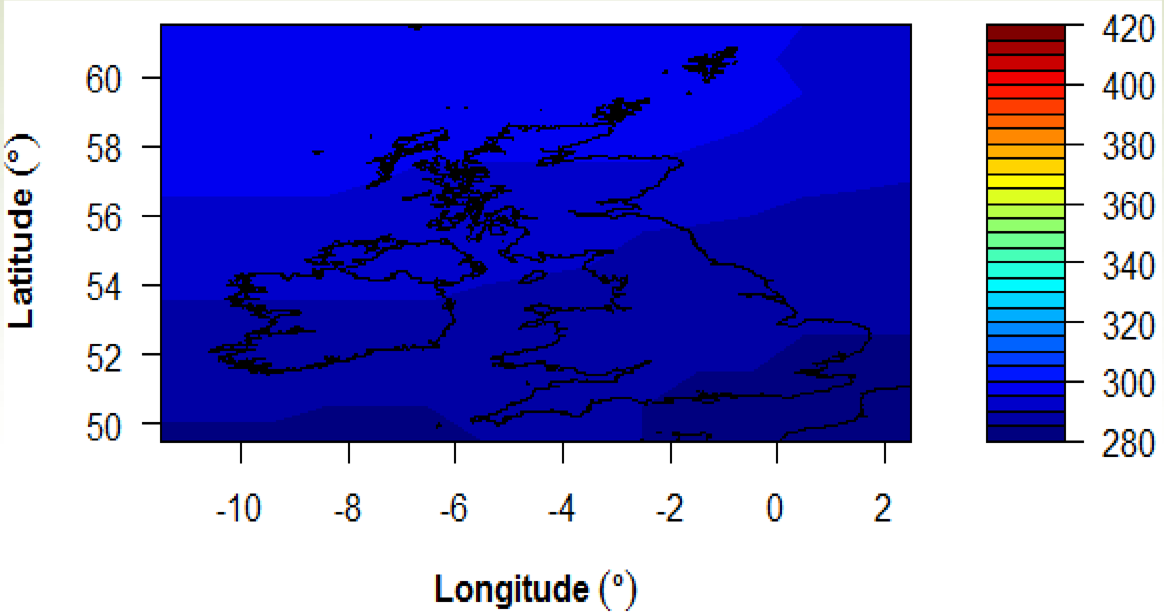
$AOD_{summer} = 2\text{-}2.5 \times AOD_{winter}$

Ångström α exponent: derived from Chilbolton, southern England ~4.5 years of level 2.0 data

Model inputs: the PROMOTE Total Ozone Record

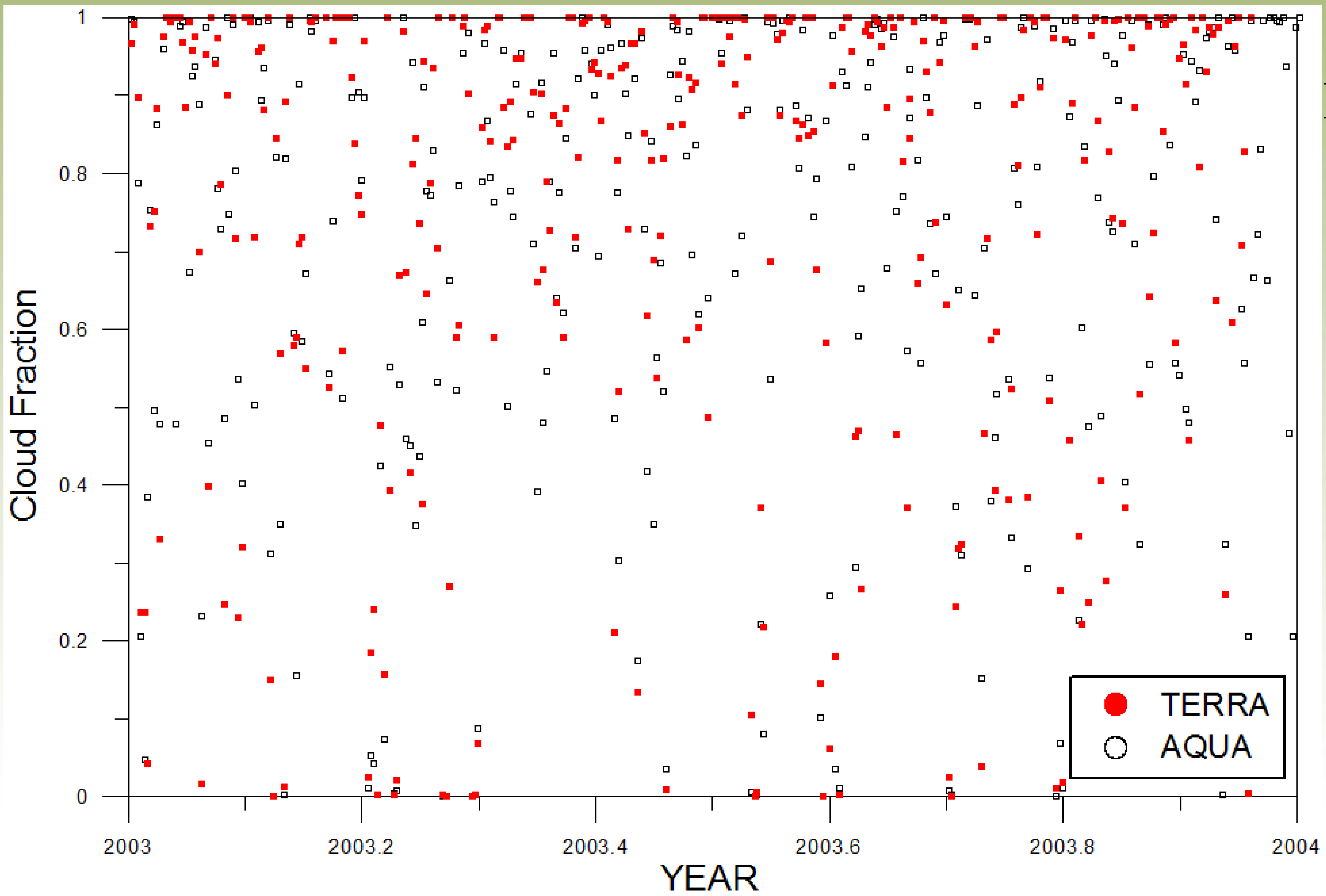


March



October

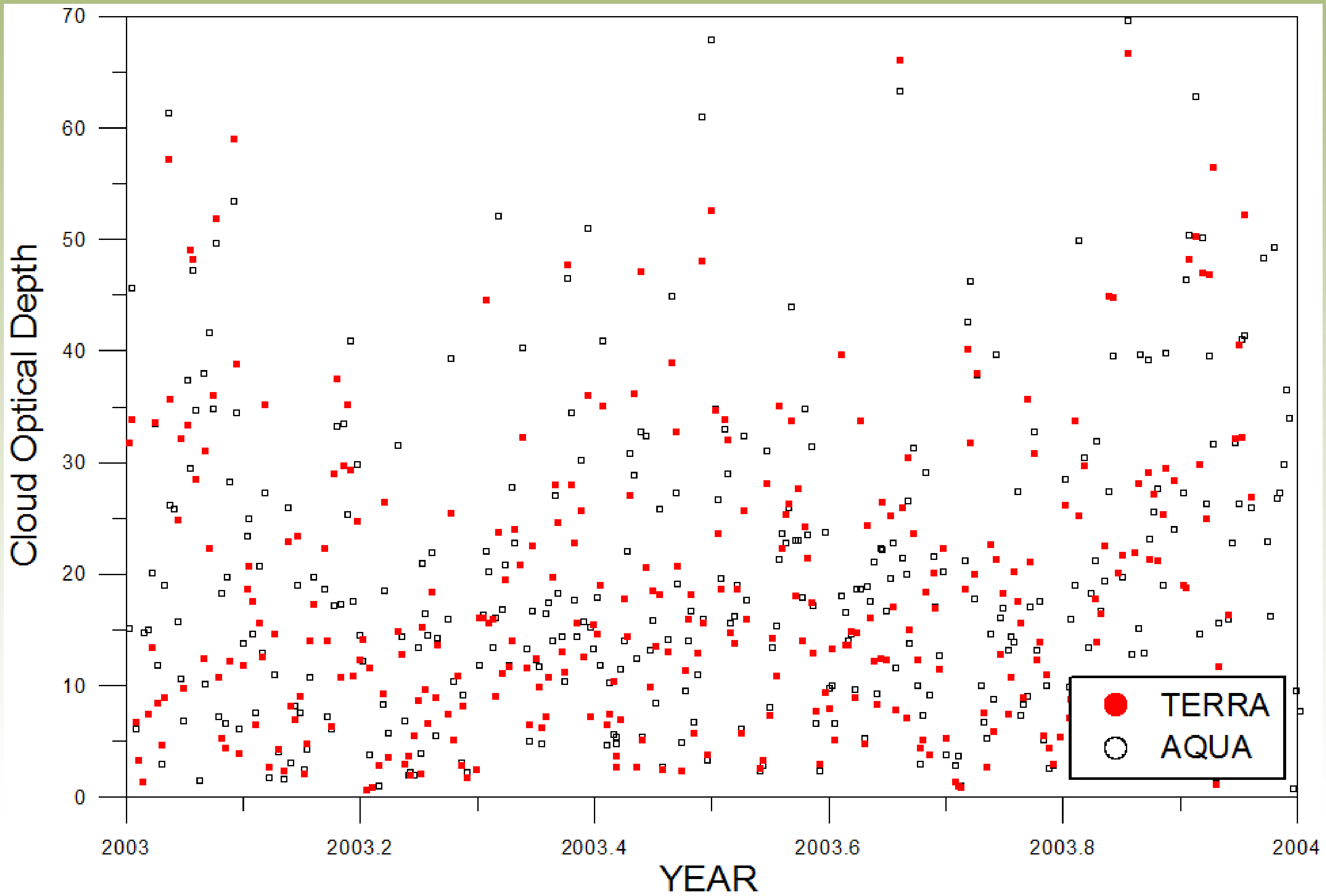
Model inputs: the MODIS cloud fraction



More clouds

Less clouds

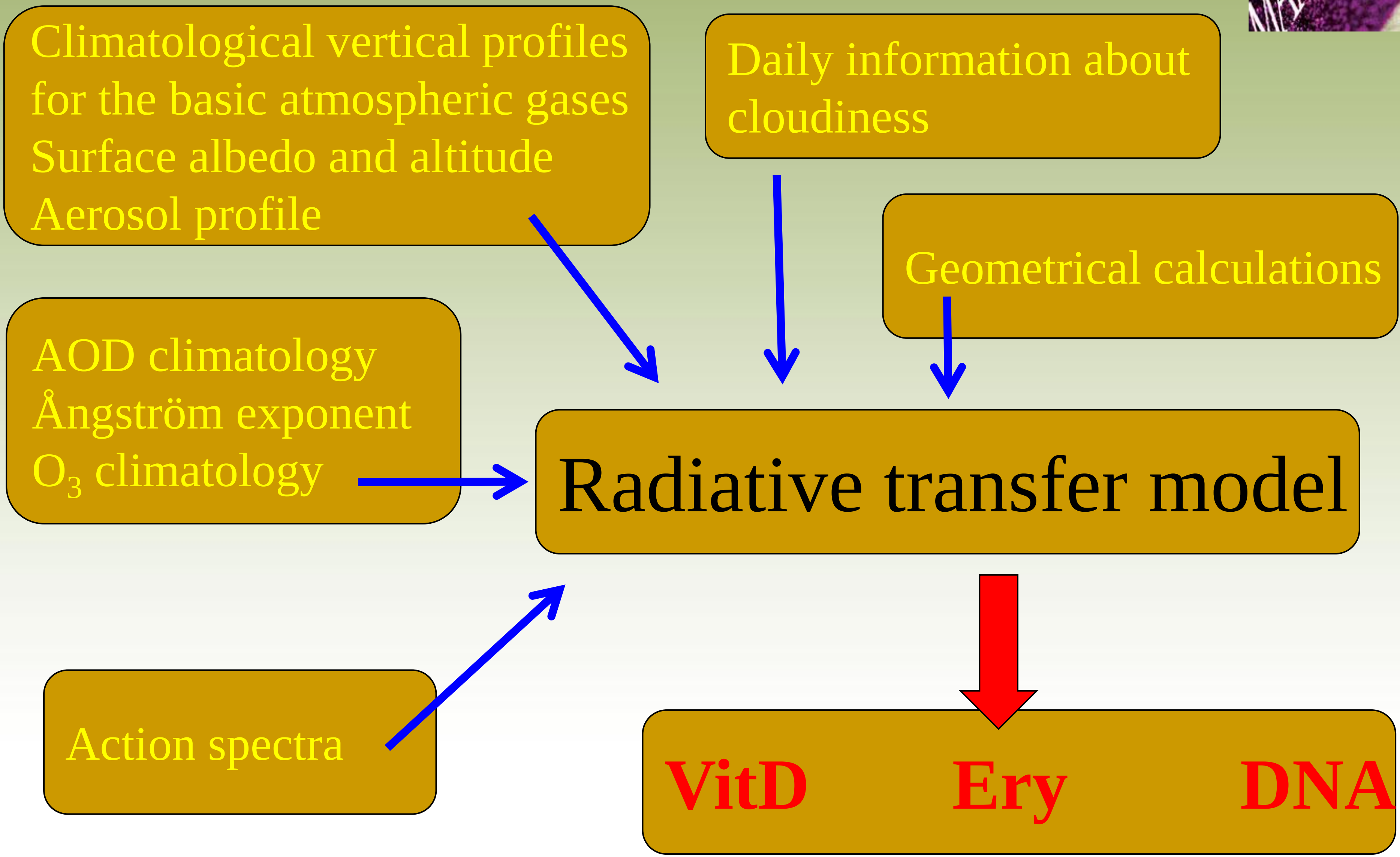
Model inputs: the MODIS cloud optical depth



Heavy clouds

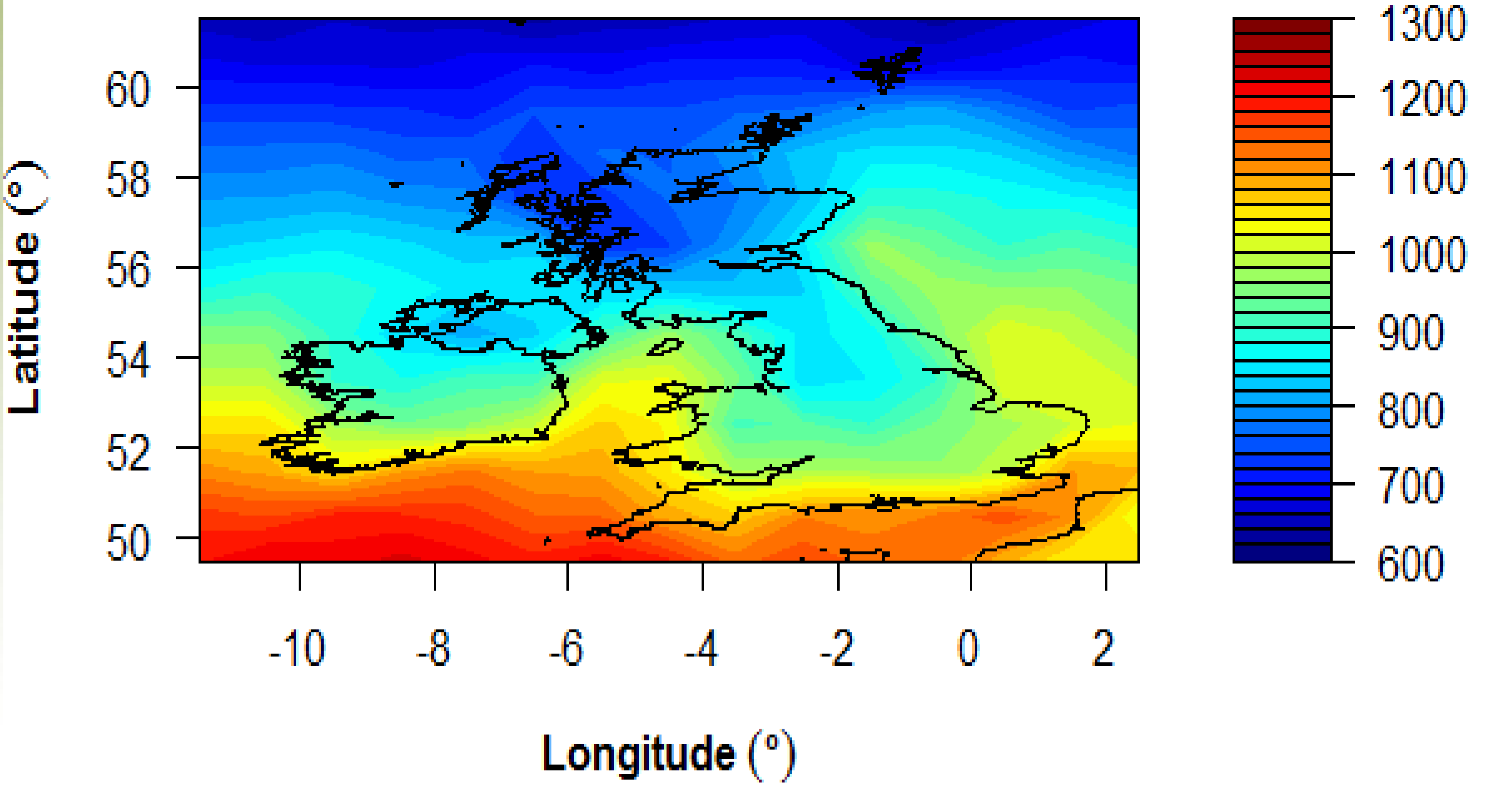
Light clouds

Calculation of UV radiation



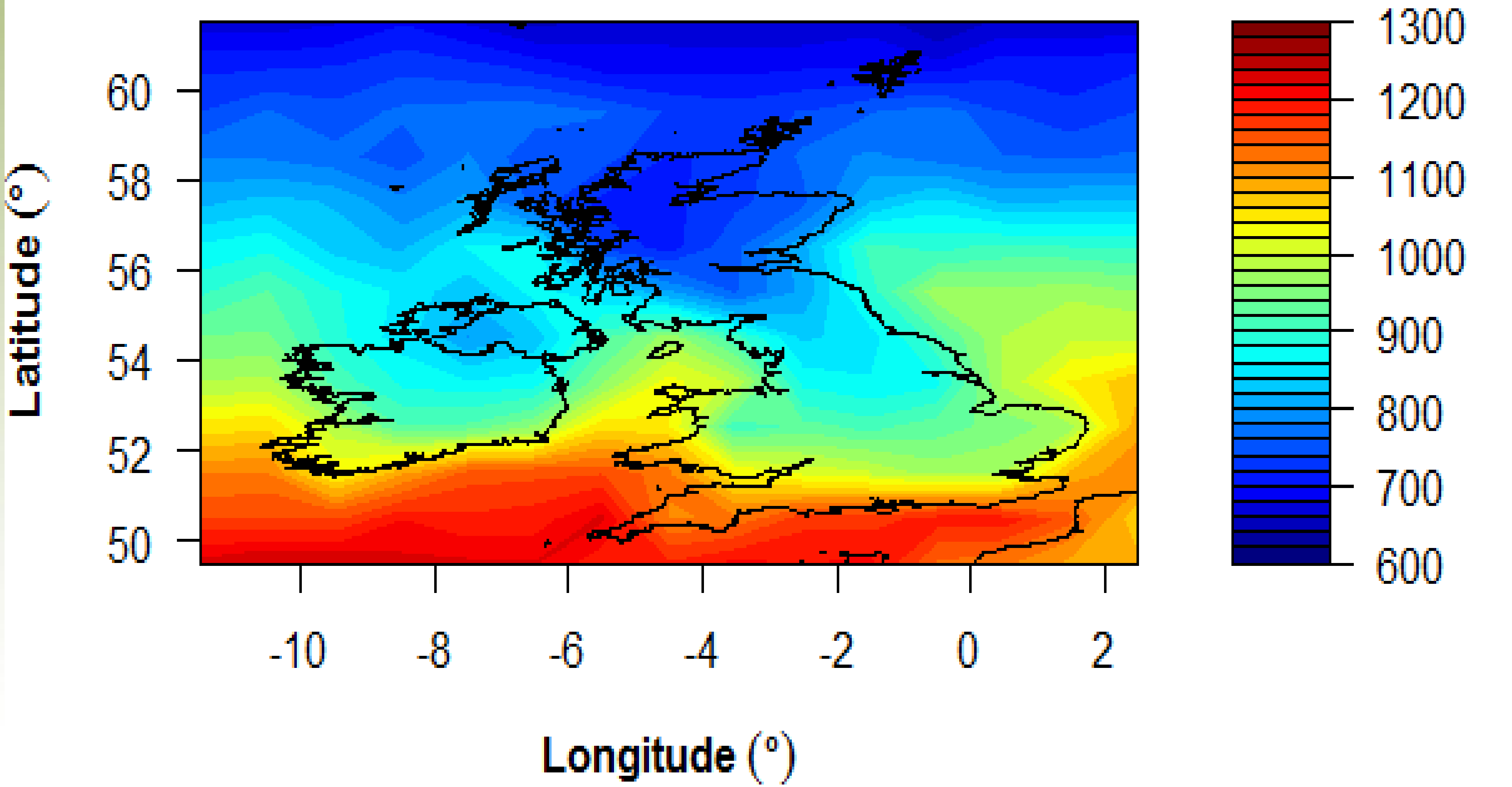
Model results- Year averages of Vitamin D dose (J/m^2)

2003



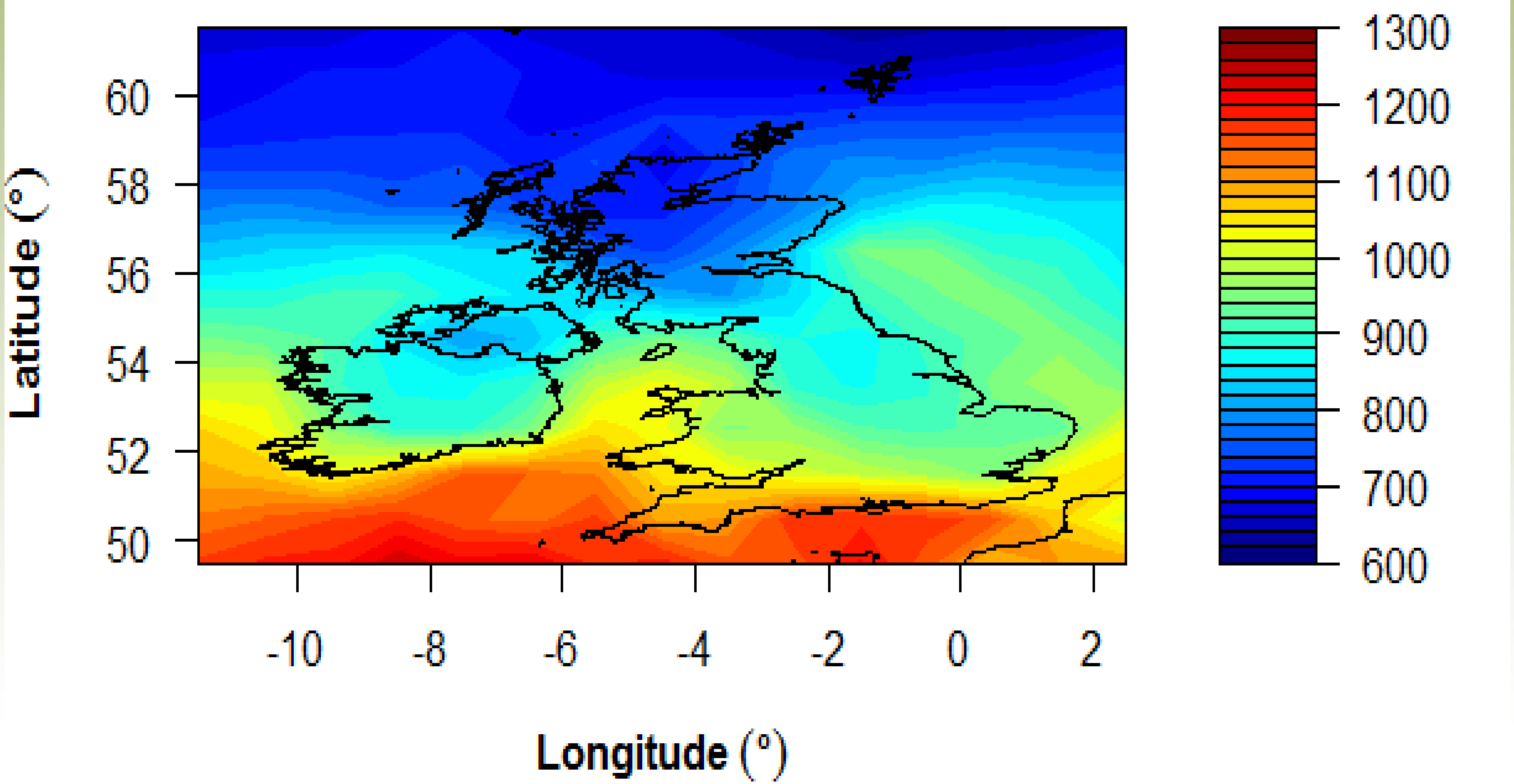
Model results- Year averages of Vitamin D dose (J/m^2)

2004



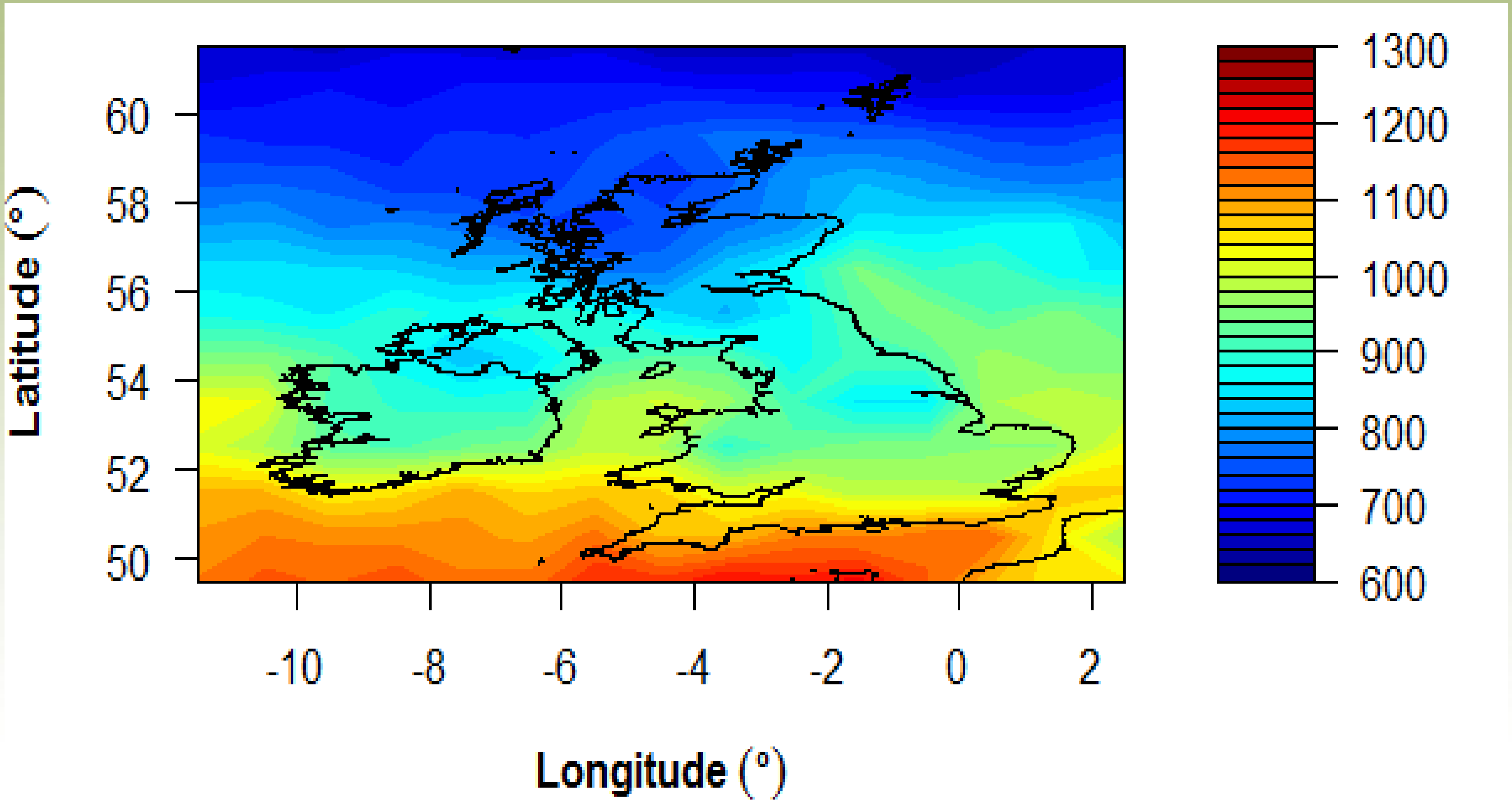
Model results- Year averages of Vitamin D dose (J/m^2)

2005



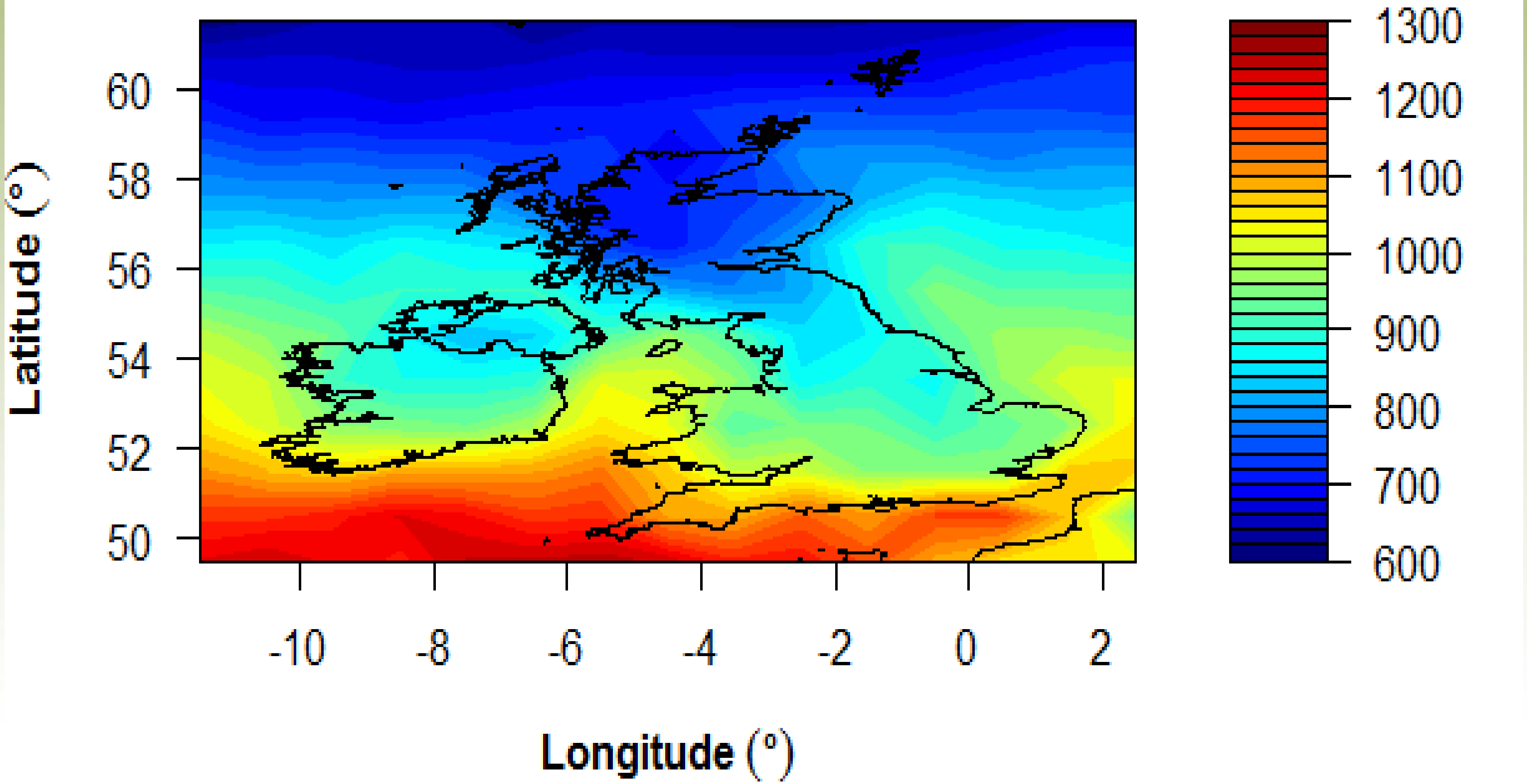
Model results- Year averages of Vitamin D dose (J/m^2)

2006



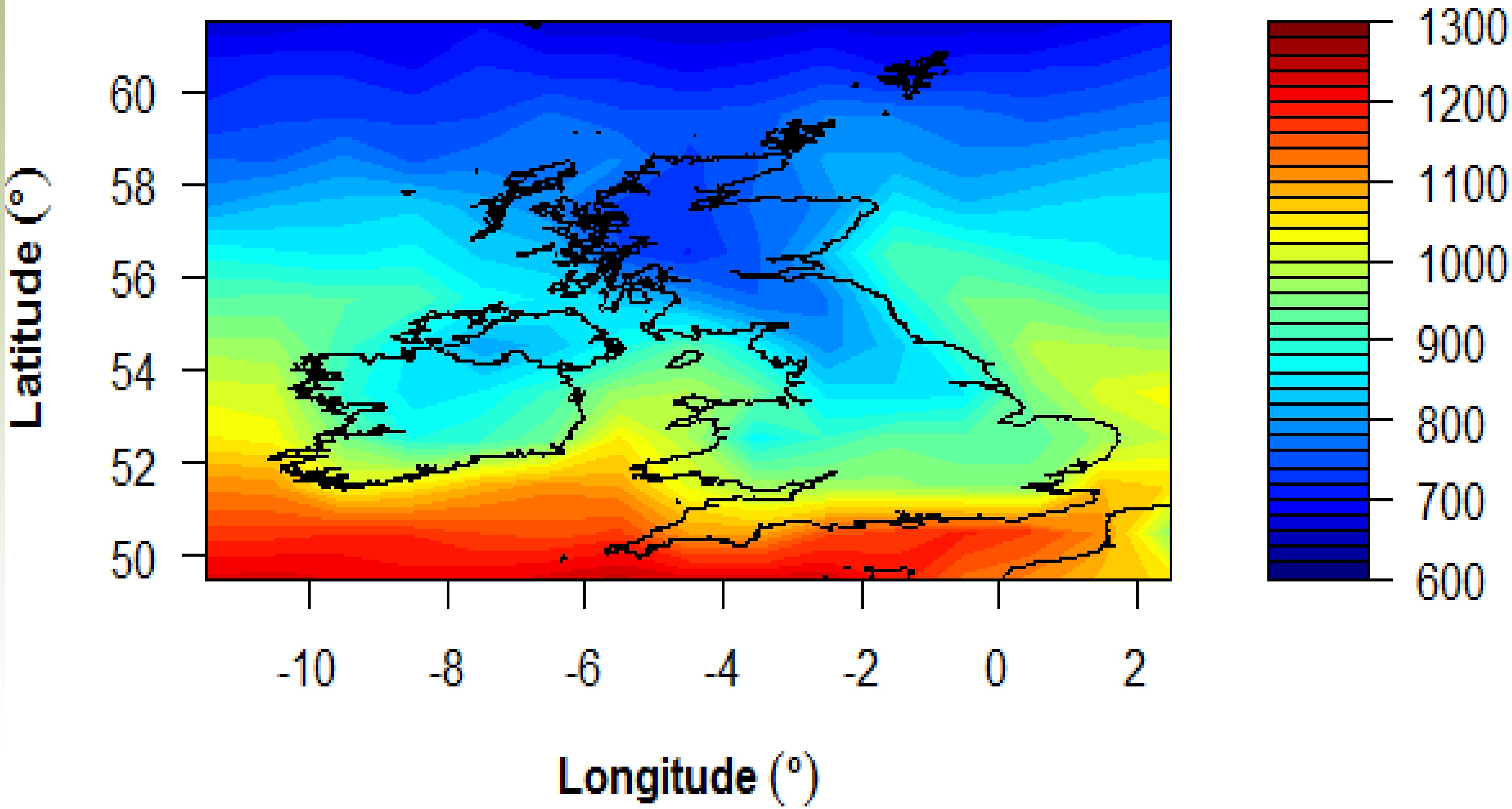
Model results- Year averages of Vitamin D dose (J/m^2)

2007



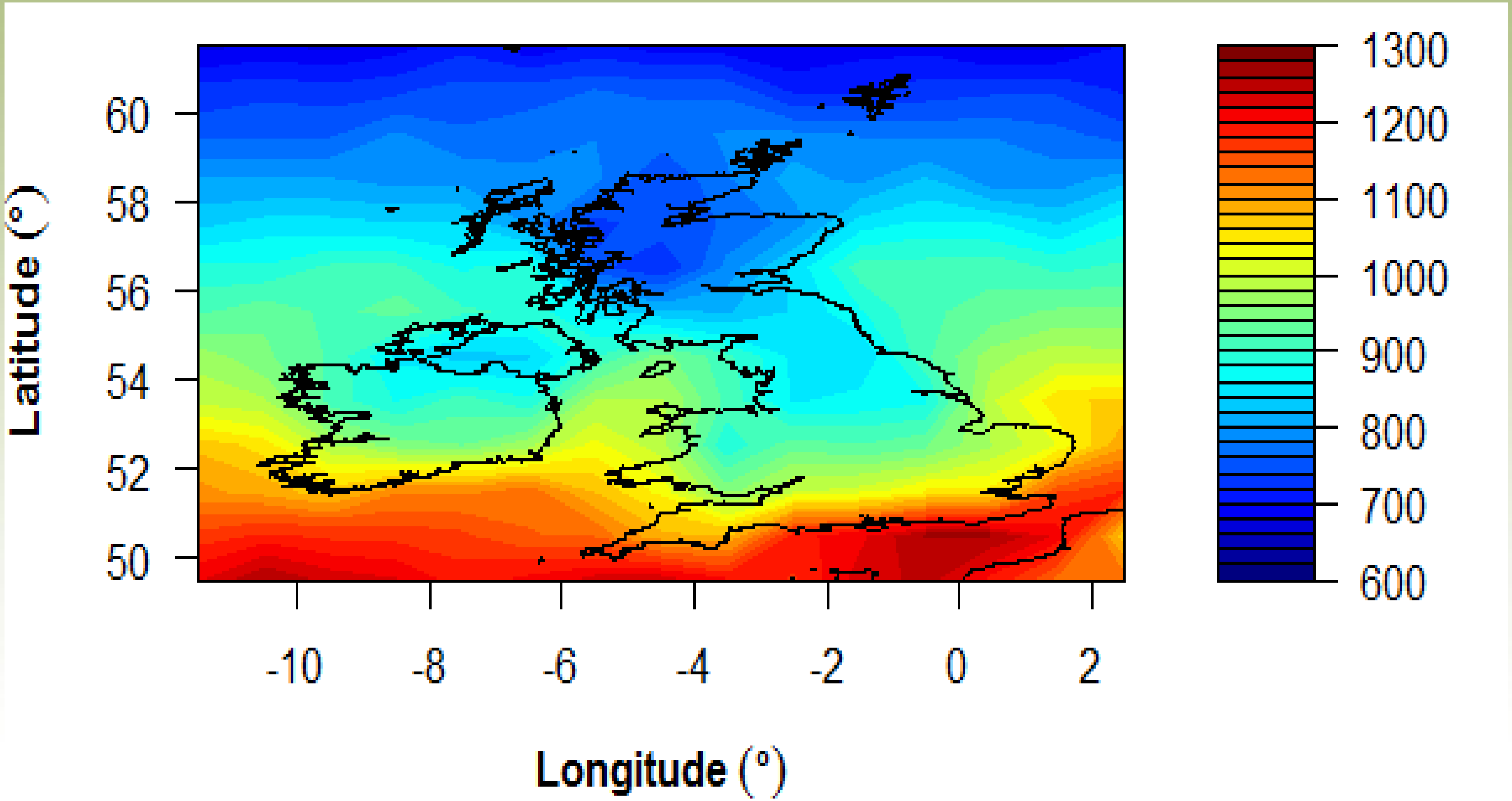
Model results- Year averages of Vitamin D dose (J/m^2)

2008



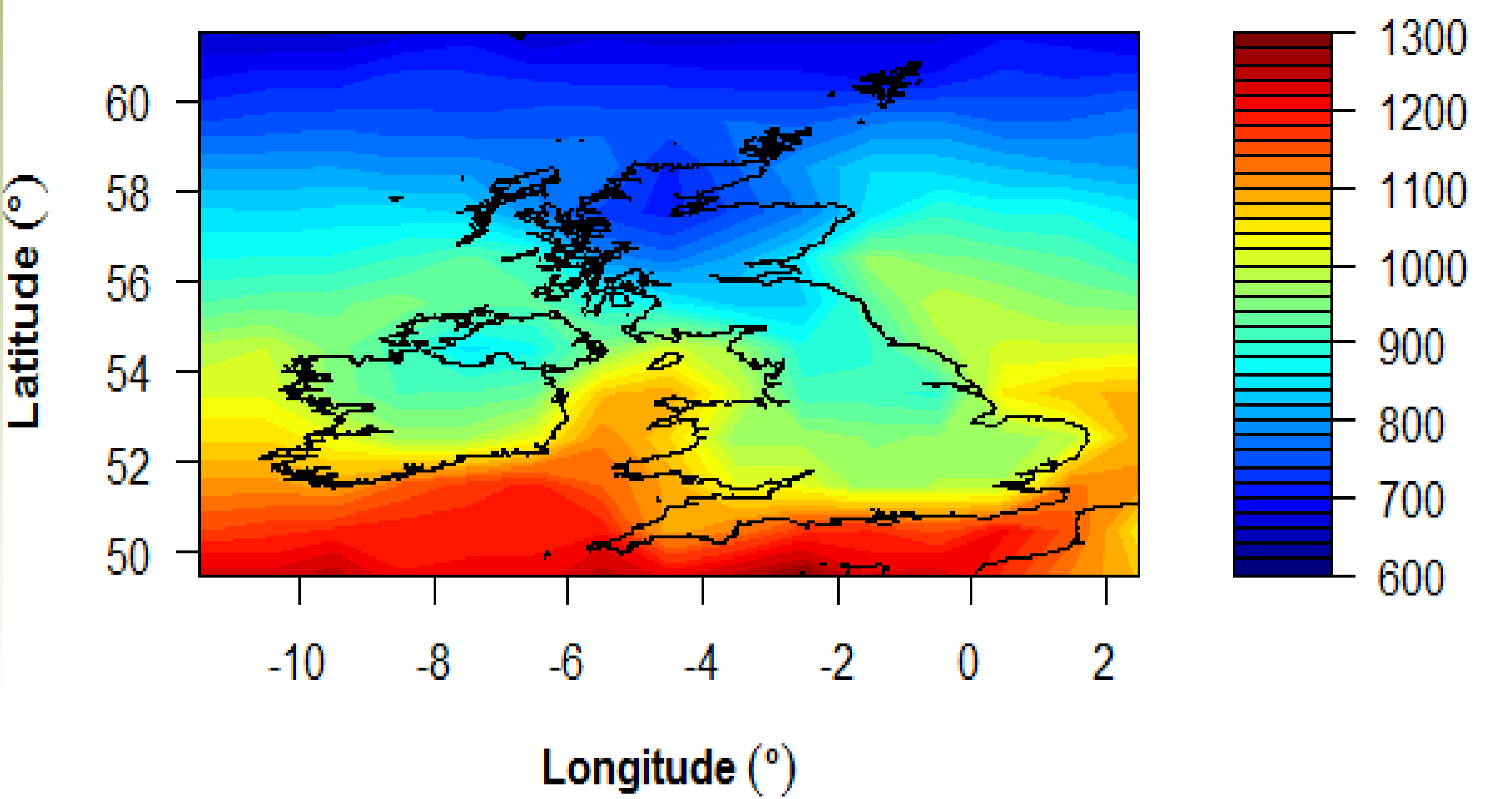
Model results- Year averages of Vitamin D dose (J/m^2)

2009



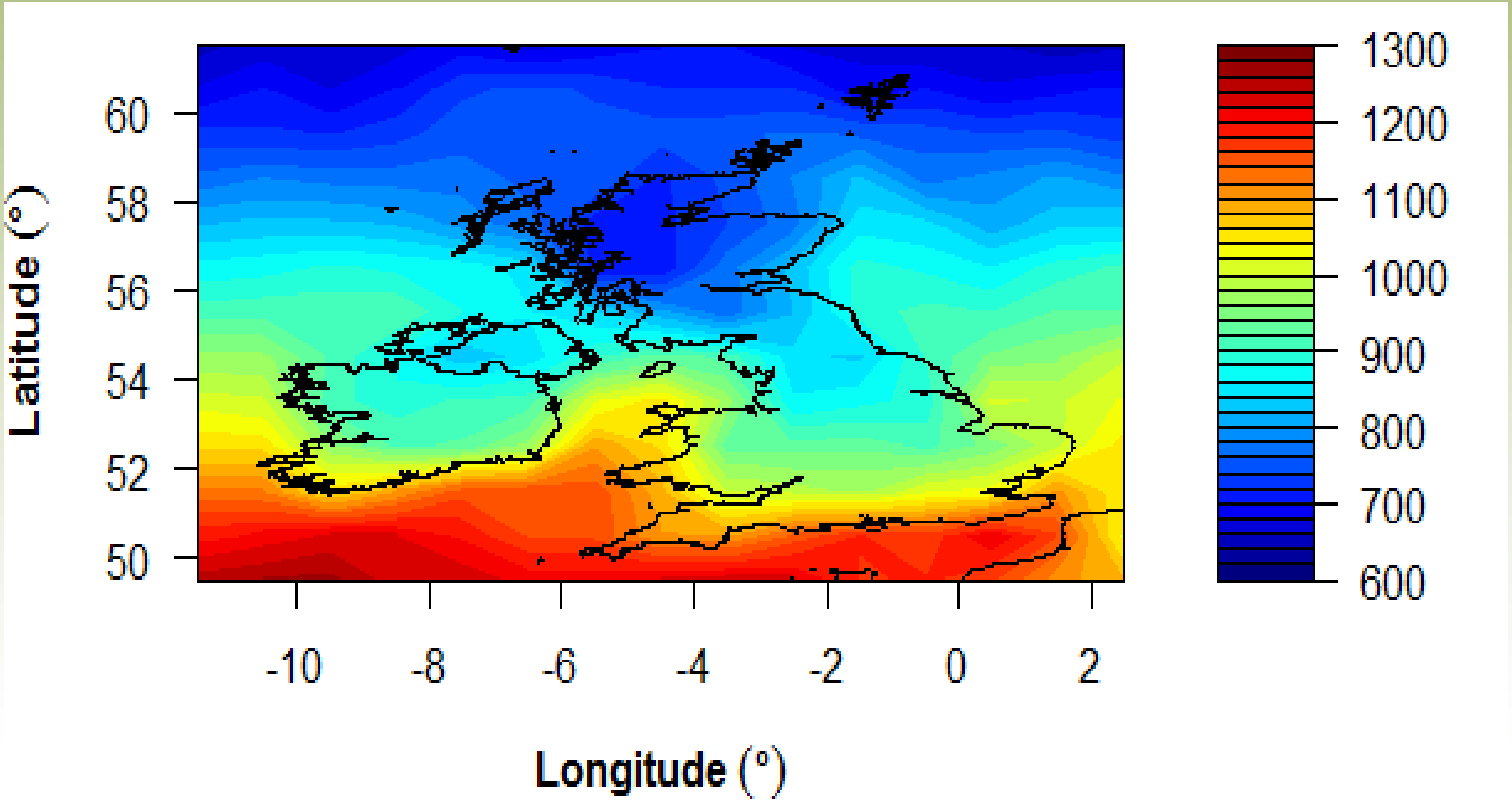
Model results- Year averages of Vitamin D dose (J/m^2)

2010



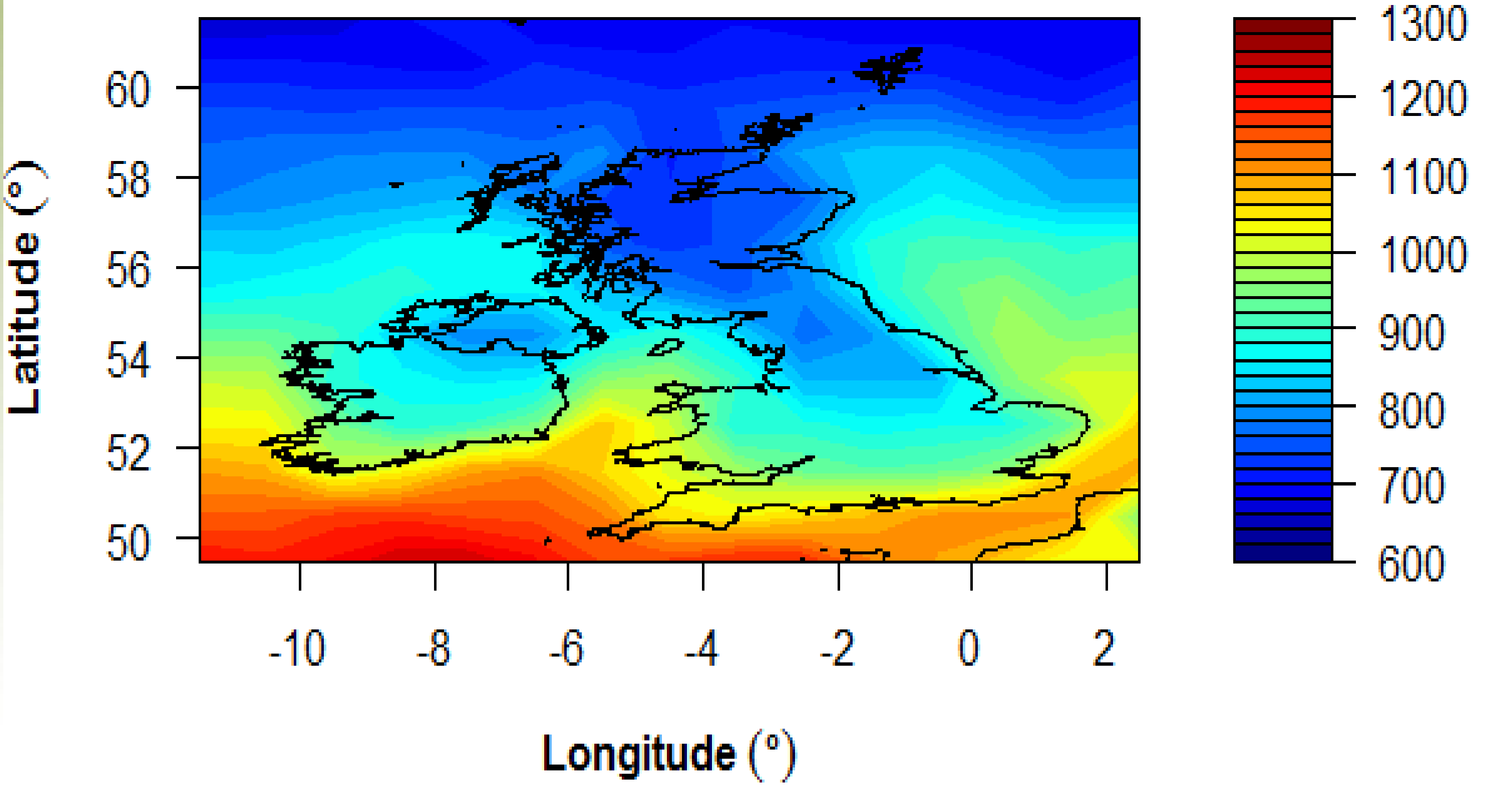
Model results- Year averages of Vitamin D dose (J/m^2)

2011

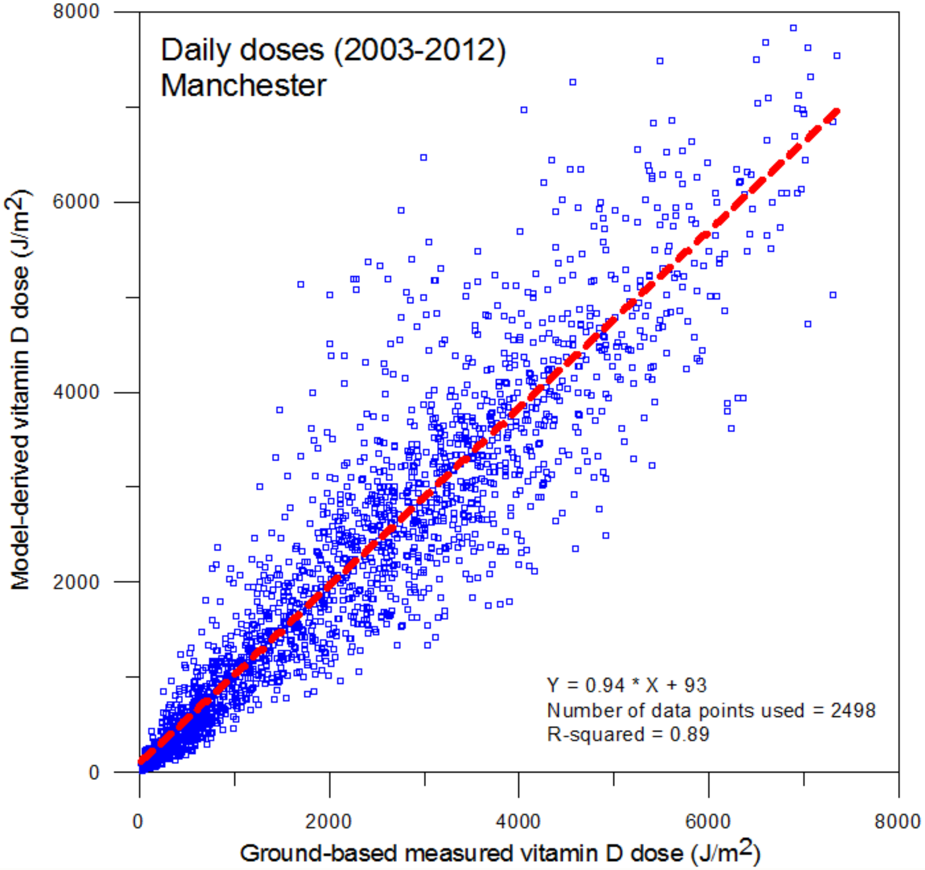


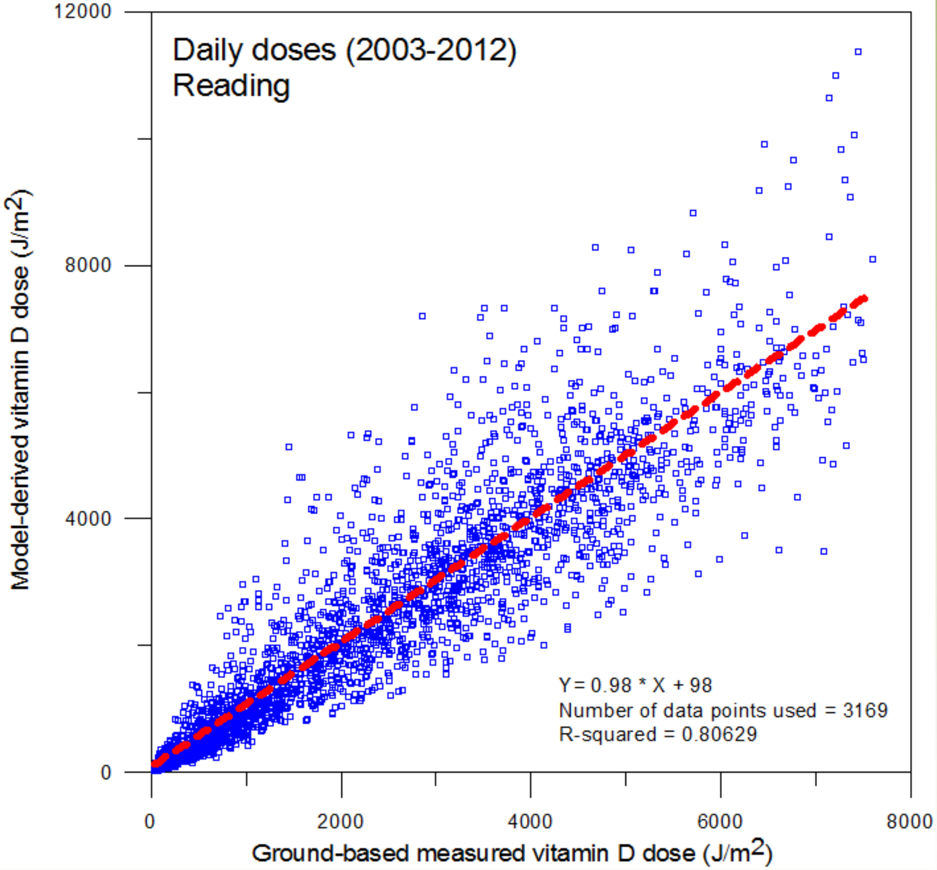
Model results- Year averages of Vitamin D dose (J/m²)

2012

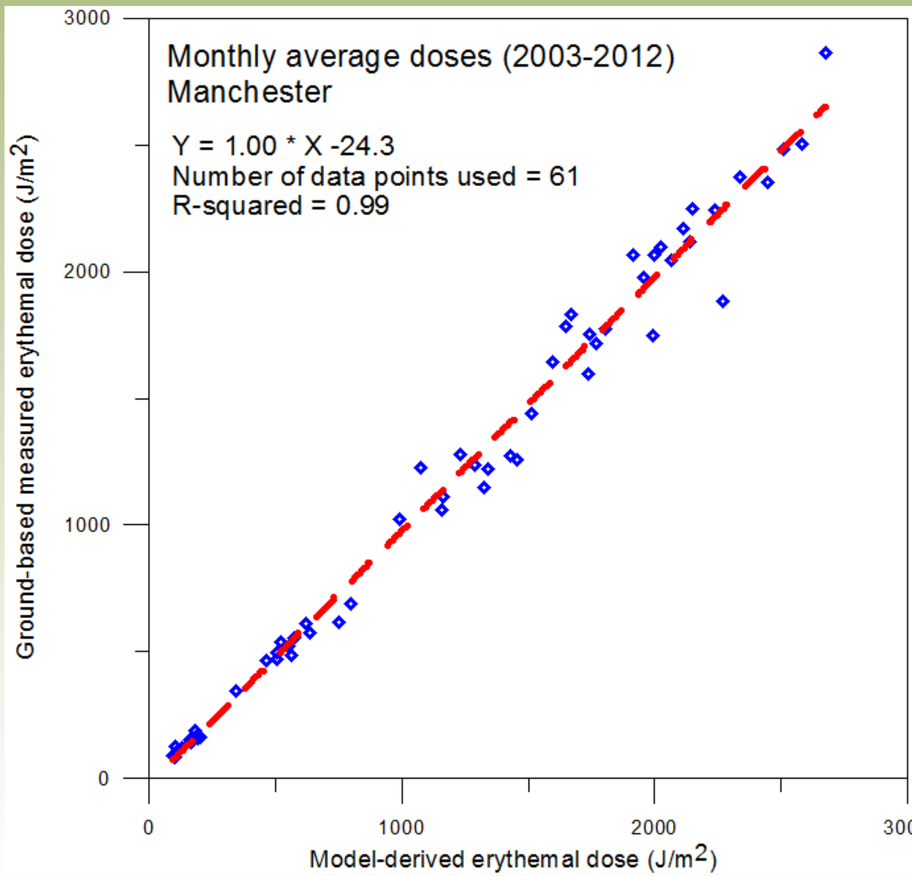


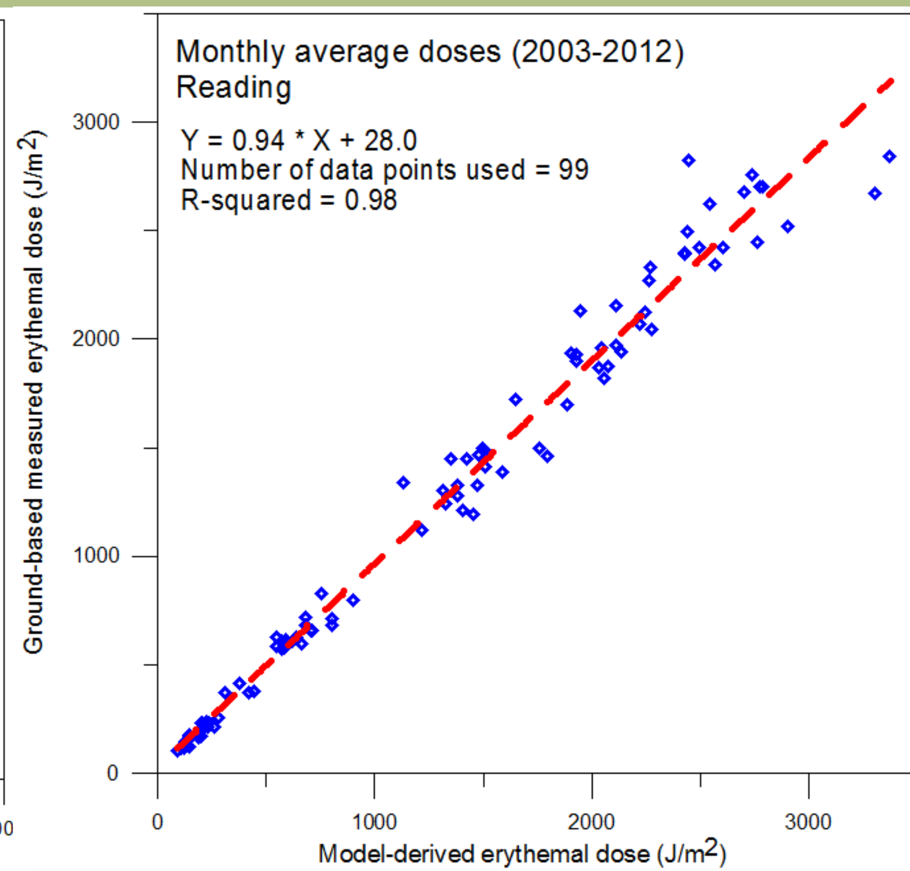
Validation of model results - spectral data



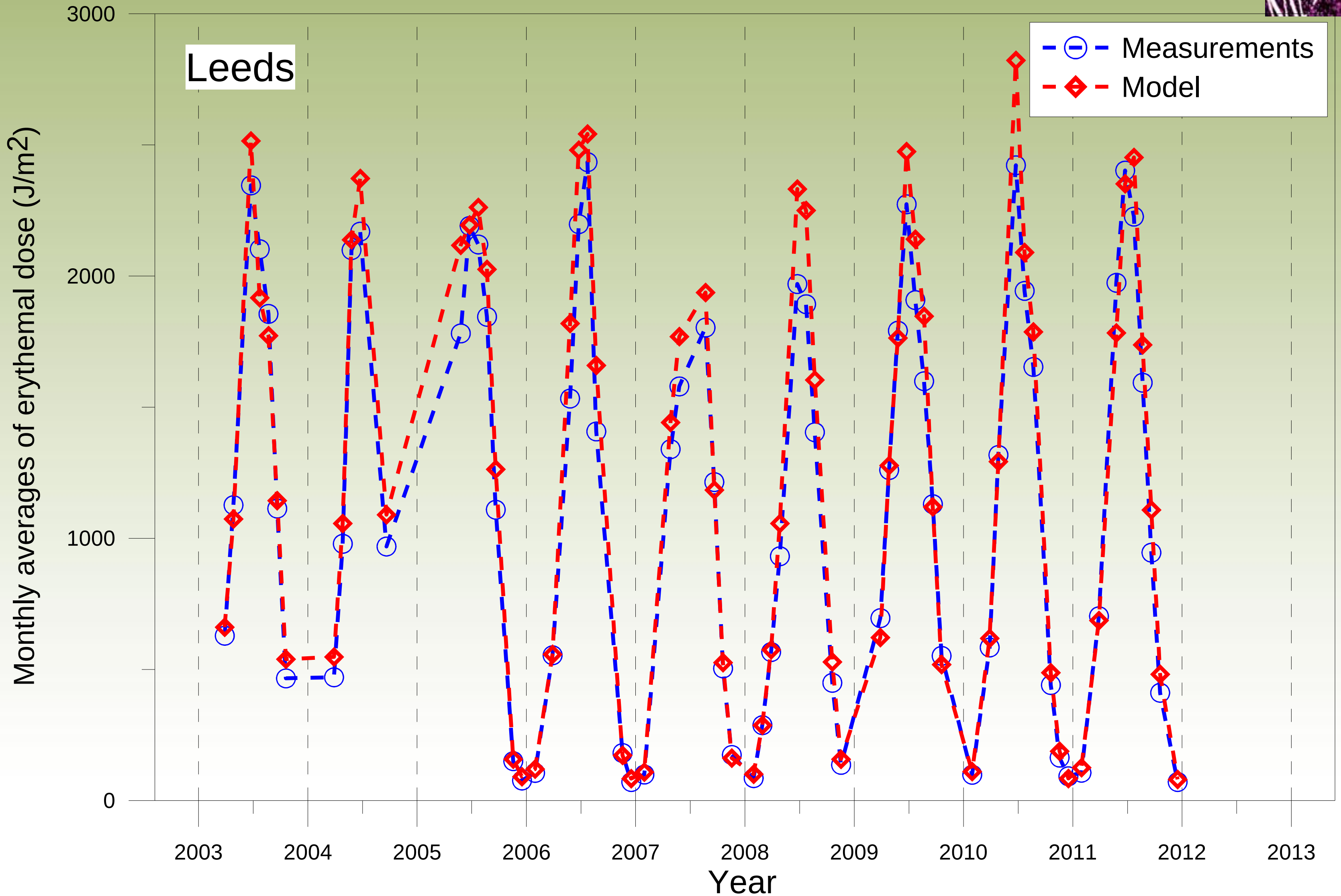


Validation of model results - spectral data

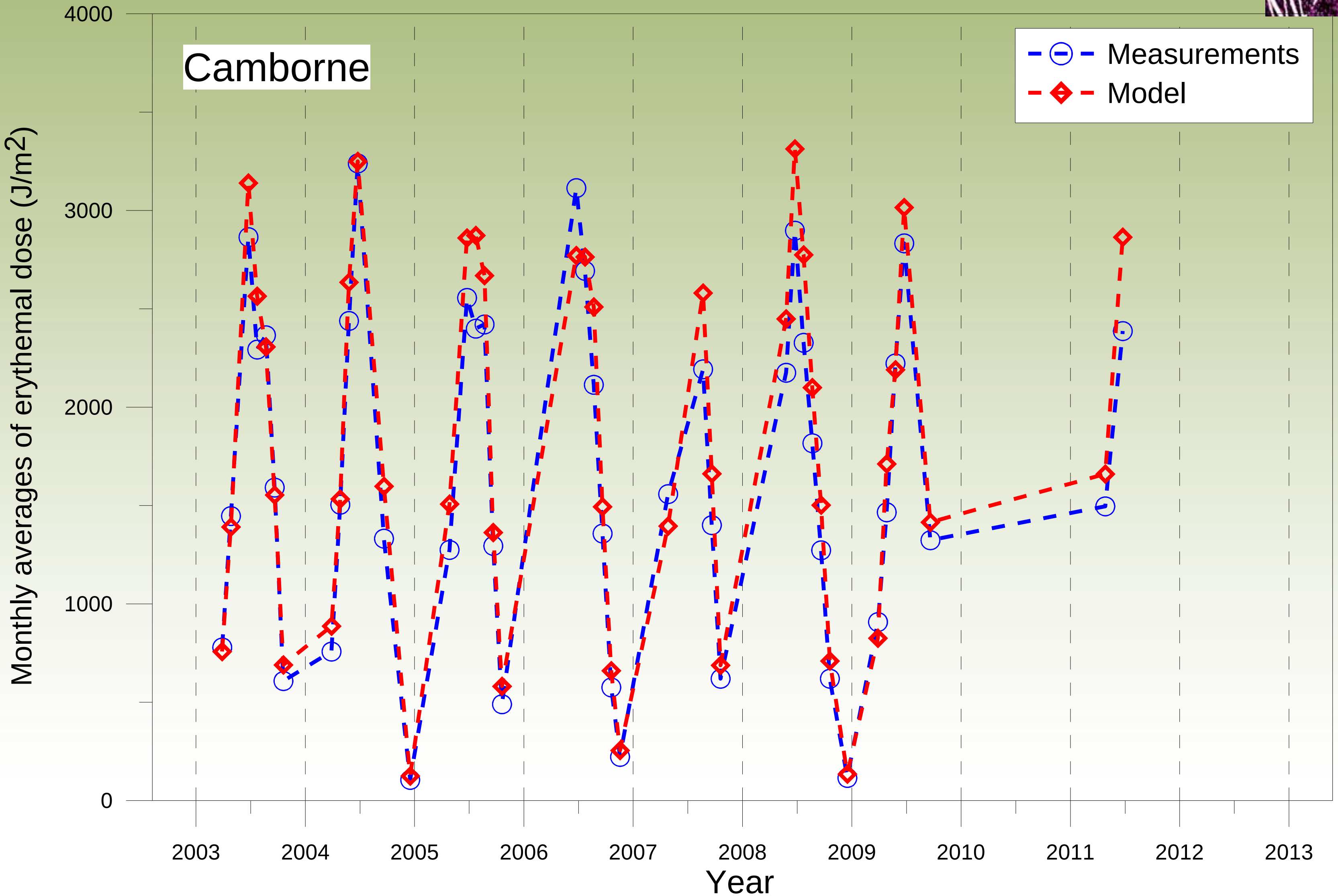




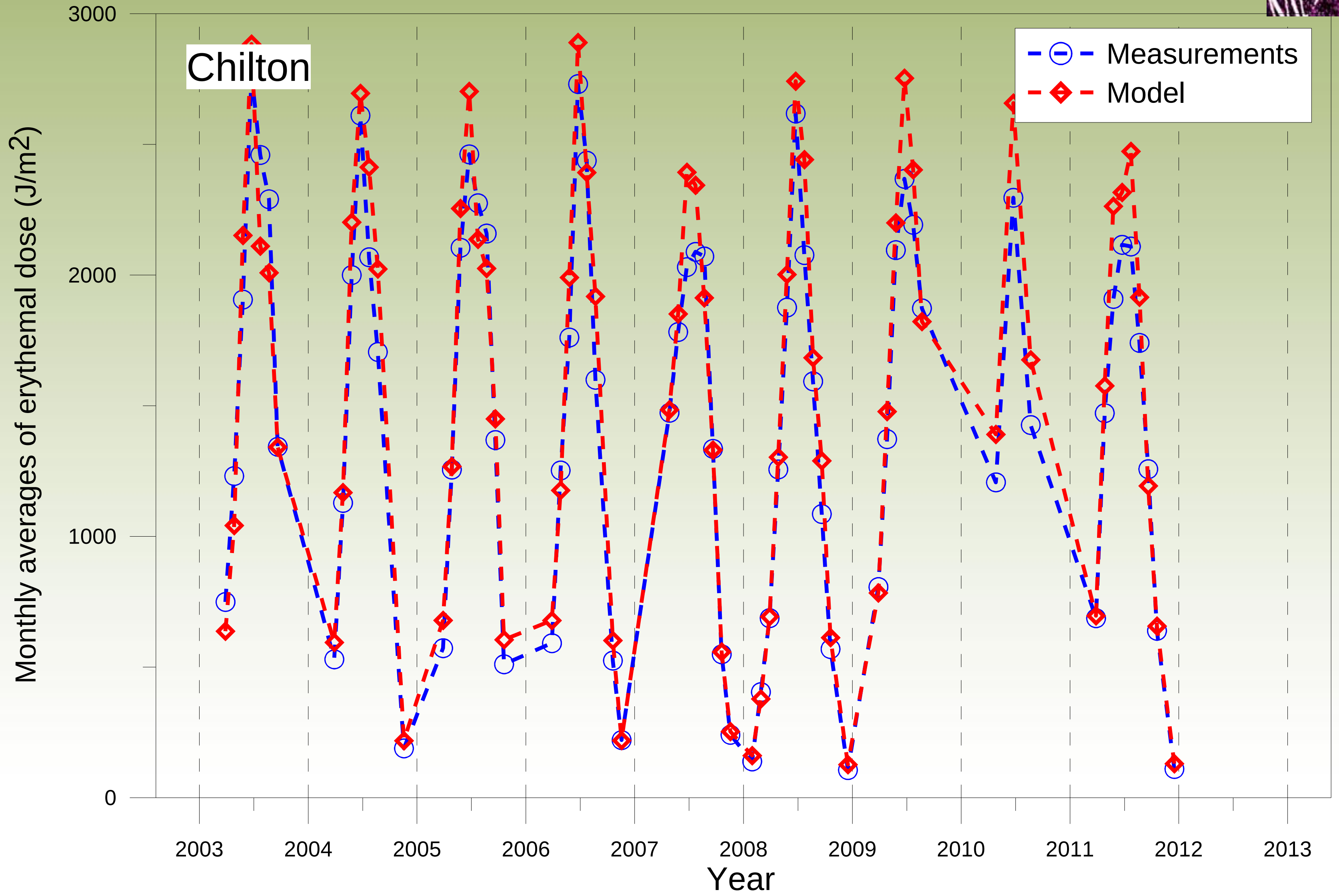
Validation of model results - broadband data



Validation of model results - broadband data



Validation of model results - broadband data



Conclusions – Future Work

- Cloudiness and total ozone data for a 10-years time period (2003-2012) have been used in synergy with climatologies for aerosol optical properties and other atmospheric constituents to derive how much UVB (vitamin D, erythemal, DNA damage doses) is available across the UK.

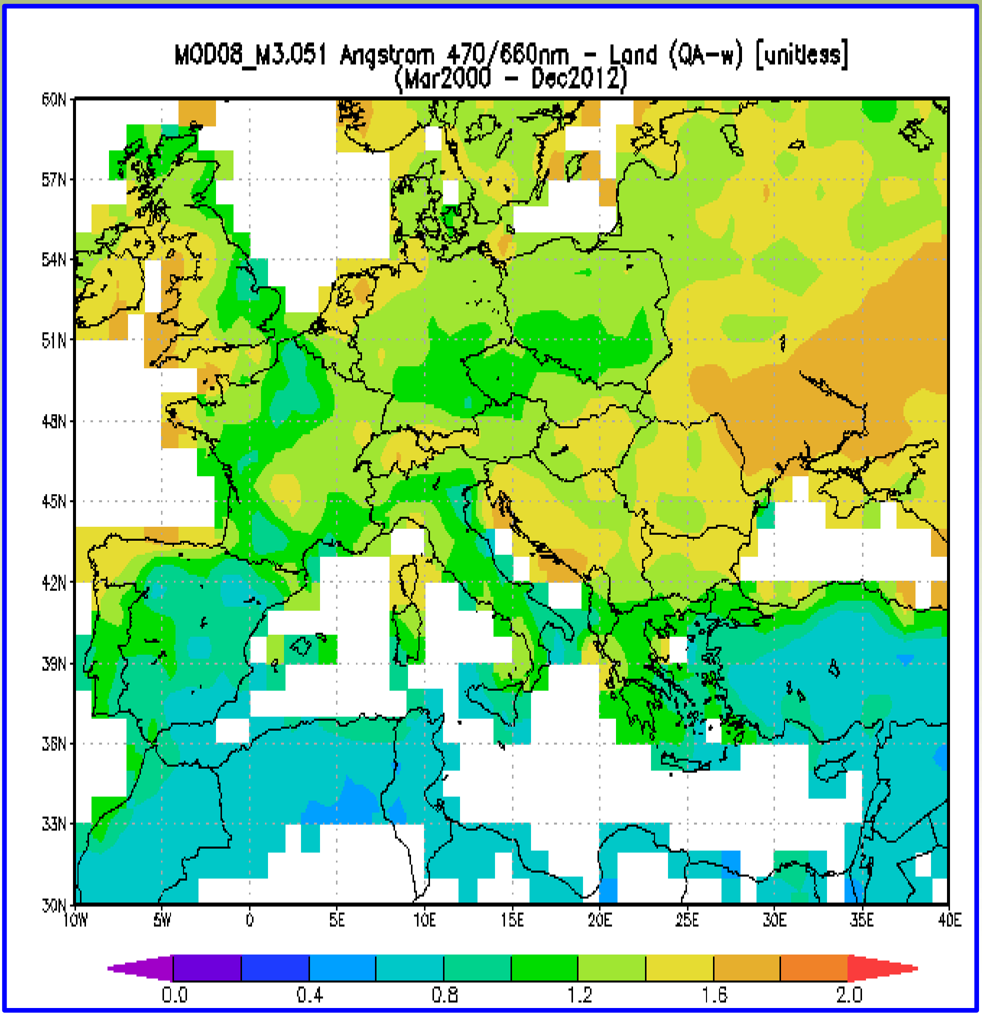
- The validation of results shows that the method is working reasonably. On a daily basis, the bias from Manchester and Reading spectral measurements is +6 and 2% respectively and is improved when monthly averages are compared. The bias from the monthly averages derived from the PHE broadband instruments is 8-10%.

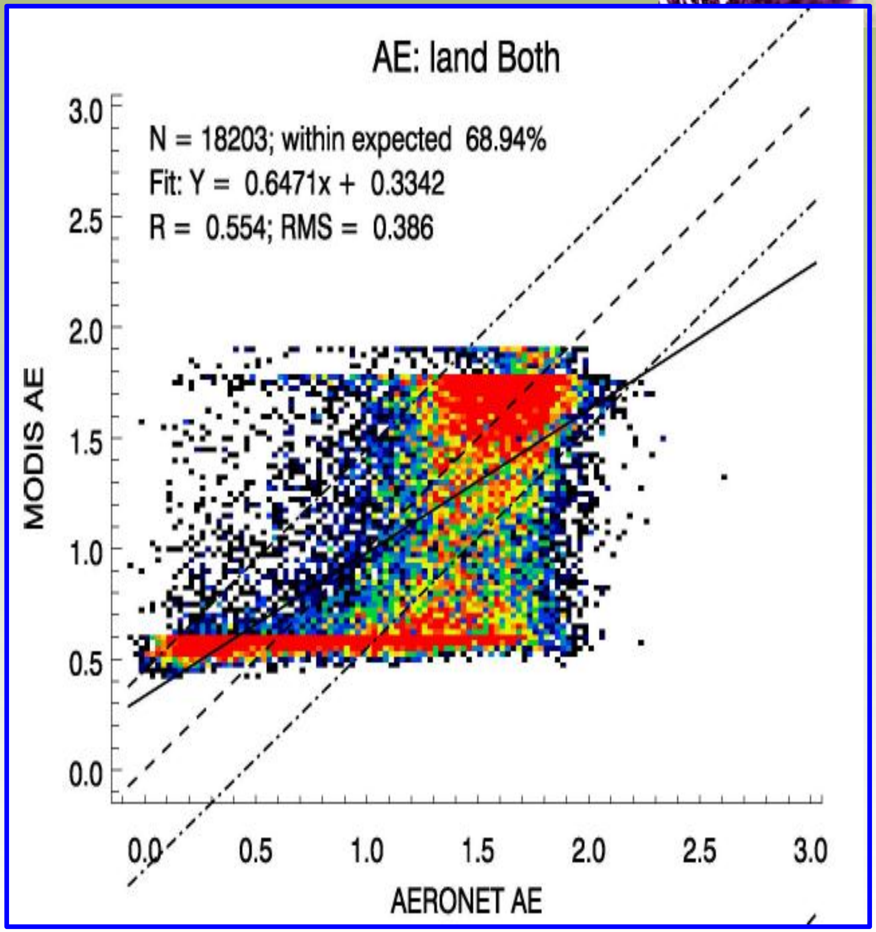
- The combined use of ambient UVB estimates with results derived from previous and on-going cohort studies across the 4 seasons in everyday life in White Skin/Photosensitive/S. Asian adults and S. Asian adolescents will reveal how much of this radiation are people exposed and what effect does this has on vitamin D status.

Acknowledgements

- The principal investigators of the AERONET station at Chilbolton, Dr. I.H. Woodhouse and J. Agnew
- Public Health England (J. O’ Hagan, A. Pearson) for providing the broadband UV measurements
- The MODIS teams for providing the Collection 5 aerosol and cloud products.
- Royal Netherlands Meteorological Institute (KNMI) for providing the PROMOTE Total Ozone Record
- The LibRadtran team for providing the model algorithm.

The MODIS Ångström exponent





Levy et al., ACP, 2010

The AOD at 550 nm is taken from the MODIS Terra **daily** Level-3 data (Collection 5.1) which have a spatial resolution of 1° x1°